

Study in respect of origin, distribution of species, wild relatives and forms and major breeding procedures.

RICE (*Oryza sativa*) $2n = 24$

Rice is the world's most important food crop grown in more than hundred countries of the world.

Origin: S.E. Asia

Distribution:

It is grown in humid tropical and subtropical climate and 90 per cent of the rice is produced and consumed in S.E. Asia. Rice producing countries are China, India, Japan, Korea, Pakistan, Bangladesh and other S.E. Asian countries. In India A.P, Karnataka, Tamilnadu, Orissa etc.

Rice is one of the oldest cultivated crops. The two cultivated species of rice are

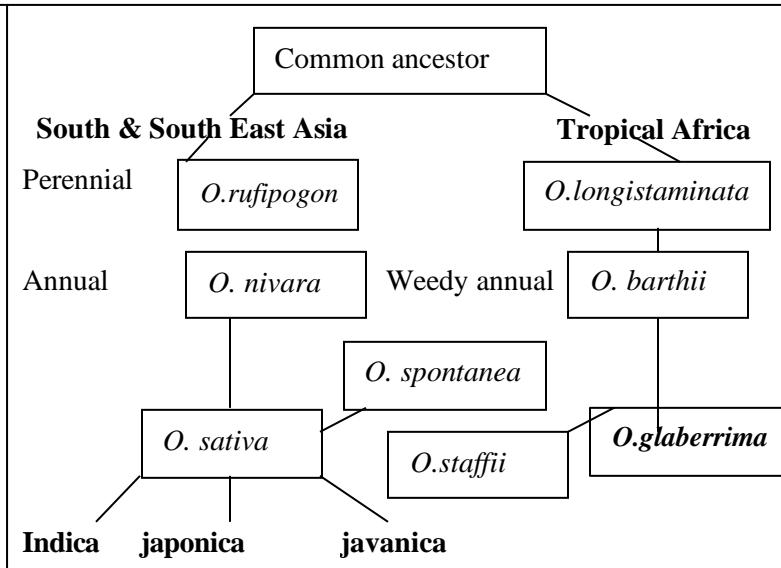
- i) *Oryza sativa* - Asian rice
- ii) *O. glaberrima* - African rice.

Origin of cultivated rice.

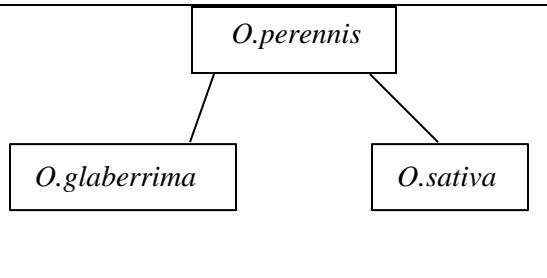
The views regarding the origin of rice can be grouped in to two classes viz.,

- a) Polyphyletic origin
- b) Monophyletic origin.

i. **Polyphyletic:** Originated from several species. According to this theory, the two forms of cultivated rice viz., Asian rice *O.sativa* and African rice *O.glaberrima* have evolved independently in their respective regions from several species.



ii. **Monophyletic** : According to this theory both Asian rice and African rice arose from a common parent (*O.perennis*). This view is the most accepted one because both Asian rice and African rice are similar except in glume pubescence, ligule size and colour of pericarp which is red in African rice.



According to polyphyletic origin the present day rice varieties have originated from several species. According to monophyletic origin a single species has given rise to all varieties of cultivated rice. viz.,

Oryza sativa

Oryza glaberrima

most of the modern rice workers believe that origin of cultivated rice monophyletic. From *oryza perennis* rose the Asian rice in South East tropical Asia and African rice in the upper valley of Niger River in Africa.

CLASSIFICATION

The three sub species or races of cultivated Asian rice (*Oryza sativa*) are

- i) Indica
- ii) Japonica (Sinica)
- iii) Javanica.

S. No.		INDICA	JAPONICA	JAVANICA
1	Distribution	Tropical Ex. Asia India	Sub-tropical to warm temperate Ex. Japan	Intermediate Sub-Tropical Ex. Indonesia
2	Leaves	Broad, Light green	Narrow, Dark green	Broad, Stiff
3	Tillering	Profuse	Medium	Low
4	Height (Stature)	Tall	Short Plant	Tall
5	Grains	Slender-Flat	Short-Roundish	Broad, thick grains
6	Resistant			
a)	Temperature	Sensitive	Resistant	Resistant
b)	Drought	Resistant	Intermediate	Sensitive

Species in the genus *oryza*:

According to the latest view the genus *oryza* include 20 wild species. Out of these two are cultivated diploids viz. *O.sativa* and *O.glaberrima* and rest are wild species which include both diploid and tetraploid forms.

Botanical name	Chromosome No.	Genome	Origin
<i>O.sativa</i>	24	AA	Asia
<i>O.nivara</i>	24	AA	Asia
<i>O.meridionalis</i>	24	-	Australia
<i>O.longistaminata</i>	24	AA	Africa

<i>O.rufipogon</i>	24	AA	Asia
<i>O.glumaepatula</i>	24	-	America
<i>O.grandig lumis</i>	48	CCDD	America
<i>O.glaberrima</i>	24	AA	Africa
<i>O.barthii</i>	24	AA	Africa
<i>O.australiensis</i>	24	EE	Australia
<i>O.latifolia</i>	48	CCDD	America
<i>O.alata</i>	48	CCDD	America
<i>O.eichingeri</i>	24	CC	Africa
	48	BBCC	
<i>O.minuta</i>	48	BBCC	Asia
<i>O.punctata</i>	48	BBCC	Asia
<i>O.officinalis</i>	24	CC	Asia
<i>O.granulata</i>	24	-	Asia
<i>O.meyeriana</i>	24	-	Asia
<i>O.ridleyi</i>	48	-	Asian
<i>O.longiglumis</i>	48	-	New Guninea
<i>O.brachantha</i>	24	FF	Africa
<i>O.schlechter</i>	-	-	New Guinea

RICE

Related species of rice and their contributing characters in rice improvement.

Species	Genome	Useful traits
<i>O.alata</i>	CCDD	High biomass production
<i>O.australiensis</i>	EE	Drought tolerance, BPH resistance
<i>O.barthii</i>	AA	Drought avoidance, BLB resistance
<i>O.brachyantha</i>	FF	Yellow stem borer and leaf folder resistance
<i>O.eichengeri</i>	CC	BPH, GLH, WBPH resistance
<i>O.grandi glumis</i>	CCDD	High biomass production
<i>O.granulata</i>	unknown	Shade tolerance, adaptation to aerobic soils
<i>O.latifolia</i>	CCDD	High biomass production
<i>O.longistaminata</i>	AA	Drought tolerance
<i>O.meridionalies</i>	AA	Elongation ability
<i>O.meyeriana</i>	Unknown	Shade tolerance, adaptation to aerobic soils
<i>O.minuta</i>	BBCC	BPH, GLH, WBPH, BLB and blast resistance
<i>O.nivara</i>	AA	Grassy stunt virus resistance

<i>O.officinalis</i>	CC,BB,CC	BPH, GLH, WBPH resistance BPH resistance
<i>O.prnetate</i>	BB, BBCC	BPH resistance
<i>O.ridleyi</i>	unknown	Shade tolerance, stemborer, blast and BLB resistance
<i>O.rufipogon</i>	AA	Source of CMS

BREEDING OBJECTIVES:

1. High yield potential
2. Adaptability and stability of yield
3. Maturity early, medium and long
4. Resistance to lodging and shattering
5. Resistant to cold temperature.
6. Resistant to salinity and alkalinity
7. Resistant to diseases like blast, stem rot, Tungro, sheath blight etc.
8. Resistant to pests like stem borer, gall midge, BPH etc
9. Improved grain quality
 - a) Grain shape and size
 - b) Texture of Endosperm and quality of starch in Endosperm
 - c) Aroma & Cooking quality (Basmati type)
 - d) Colour of kernel
 - e) Milling out turn
10. Breeding for alternate source of dwarfing gene.
11. Breeding varieties suited for direct seeding
12. Breeding varieties for dry lands
13. Breeding varieties for deep water conditions
14. Breeding varieties for export - scented rice
15. Breeding varieties to control wild rice
16. Breeding varieties to suit any other local conditions .

BREEDING PROCEDURES

1. Introduction :

All the IRRI Rice varieties from IR 8 to IR 72. Other Examples are Basmati from Punjab, Ponni (mahsuri) from Malaysia, CR 1009 (Ponmani) from Orissa.

2. Pure line selection :

3. Hybridization and Selection :

a) Pedigree method

i) Inter varietal:

ii) Inter-racial

Japonica x indica cross ADT 27 (Norin 10 x GEB 24)

Ponni (Mashuri) (Taichung 65 x ME 80)

iii) Inter specific crosses

Co 31 (*O.perennis* x GEB 24) Drought resistance.

IR 34 Complex cross, one of the parent is *O.nivara*

b) Back Cross Method of breeding

4. Mutation breeding:

a) Spontaneous mutation

GEB 24

ADT 41 - Dwarf mutant of Basmati 370.

b) Induced mutation :

Jagannath rice from Orissa. Semi dwarf.

Parbhani - from Maharastra

5. Heterosis Breeding (Rice Hybrids)

APHR – 1 (IR 58025A X Vajram)

APHR – 2 (IR 62829A X MTU9992)

KRH1 (IR 58025A X IR 9761-10-IR)

CORH – 2 (IR 58025A X C 20R)

HYBRID RICE

The utilization of the dwarfing gene (d1) from the mutant variety Dee-Geo-Woo-Gen (DGWG) discovered in Taiwan in 1960s led to the development of Semidwarf, high tillering, nitrogen responsive, high yielding varieties of rice throughout the world. Consequently the yield level of rice in the tropics raised even 8-10 t/ha.

Close observation of the yield performance of HYVS had revealed that the realised yield in such varieties are showing a plateauing trend (De Datta, 1990; Pingali *et al*; 1990). Among the various strategies proposed to break the yield plateau in rice productivity, exploitation of heterosis through the development of rice hybrids had been proved to be successful.

Heterosis in rice was reported by Jones in USA as early in 1926 and Ramaiah in 1933. But the research work on hybrid rice was initiated in 1964, in China by Yuan Long Ping (Father

of hybrid Rice). The identification of ‘Wild Abortive’ or ‘WA’ type cytoplasmic male sterility in 1970 was a breakthrough in hybrid rice breeding. In 1971 China accepted Hybrid Rice Research as a national cooperative project and in the year 1976, hybrid rice became a reality in China, for the first time in world, by the release of commercial rice hybrids suited for sub-tropical and temperate zones. Since then many of the rice growing countries had accepted the strategical approach of exploitation of heterosis through the development of commercial rice hybrids and as such rice hybrids were released in countries like Vietnam (for subtropical zone), Korea (for temperate zone); besides these countries, research on hybrid rice is progressing in countries like Philippines, Indonesia, Malaysia, Thailand, United States, Egypt, Colombia and Brazil.

Although research on the commercial utilization of heterosis in rice has made tremendous gains during the last 20 years, it is still in its infancy stage because the high yield potential of hybrid rice has not been fully tapped yet. And hence various approaches are adopted in major rice growing countries of the world to maximize the yield potential advancements of hybrid rice production.

Breeding techniques for developing hybrid rice involve the following:

a) Three -line method or CGMS system

This system now a days known as CMS system, involving three lines *viz-* cytoplasmic, genic male sterile line (A), maintainer line (B) and restorer line (R) is the most commonly used method in China and outside. Until 1985, more than 95% of the CMS lines used in the commercial indica rice hybrids, were of CMS-WA type which make the hybrid rice vulnerable to biotic and abiotic stresses. And hence attempts to identify new sources of male sterile cytoplasm led to the identification of CMS system like GA (Gambiaca), Di (Disi), DA (Dwarf wild rice), BTC (Chinsurah Boro II) and IP (Ido Paddy 6). Mechanism of male sterility maintenance and hybrid seed production in three-line system given in figure-1.

Many years experience had undoubtedly proved that the CGMS system involving sporophytic and gametophytic male sterility is an effective way of developing hybrid rices and will continue to play an important role in the next decade. However there are some constraints and problems in such a system. The most serious is that yields of existing hybrid rice varieties including newly developed ones, have stagnated (Yuan, 1994). They have already reached their yield plateau, and are unable to increase the yield potential through this approach and hence new methods and materials were adopted. In this regard two-line hybrids are promising ones, to raise the yield ceiling in hybrid rice.

b) Two-line method of rice breeding

Two-line hybrids can be evolved through

- Mechanical means
- Application of gametocides
- Use of cytoplasmic male sterility (CMS)
- Use of genic male sterility (GMS)
- Use of environmentally induced genic male sterility (EGMS)

In rice EGMS system is commonly used. In EGMS systems two kinds of rice lines are made use of viz. PGMS (Photosensitive Genic Male Sterility) and TGMS (Thermosensitive Genic Male Sterility) which had been developed successfully in China. In this system male sterility is mainly controlled by one or two pairs of recessive nuclear genes and has no relation to cytoplasm. Developing hybrid rice varieties with these system has the following advantages over the classical CMS system, as given below.

- Maintainer lines are not needed.
- The choice of parents for developing heterotic hybrids is greatly broadened.
- No negative effect due to sterile cytoplasm
- Unitary cytoplasm situation of WA will be avoided.

In this system the exploitation of heterosis can be achieved by developing intervarietal and intersubspecific F_1 hybrids. In 1991, China had released hybrid combinations using this

approach, and some of these combinations out yielded the best existing hybrids by 10-20% (Yuan, *et al*; 1994)

Detailed studies about physiological and ecological requirements of EGMS lines had been made in China and Japan. Work is progressing in India and International Rice Research Institute, in Philippines to identify best suited rice hybrids through this approach, for commercial exploitation. TGMS system is considered useful in tropical and subtropical regions where as PGMS system is useful in temperate regions.

Other possible approaches to develop two-line hybrid breeding system includes identification of a genic male sterility system which would revert to male fertility response to application of growth regulators and also the chemical induction of male sterility.

c) One -line method of rice breeding

Rice hybrids can be developed and popularized through the following concepts

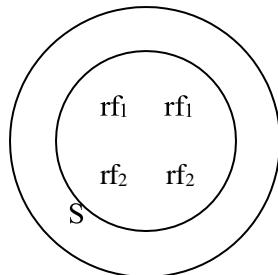
- Vegetative propagation
- Micro propagation
- Anther culture hybrids

- Apomictic lines

Among the above for large scale cultivation, apomictic lines and anther cultured materials will be economical.

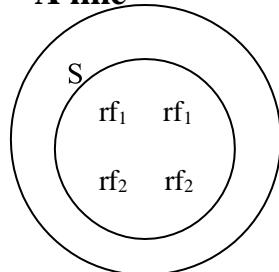
CGMS SYSTEM IN RICE

A line



Maintenance

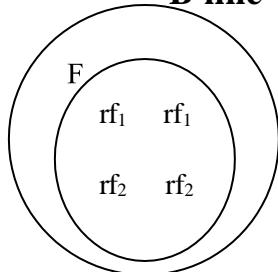
A line



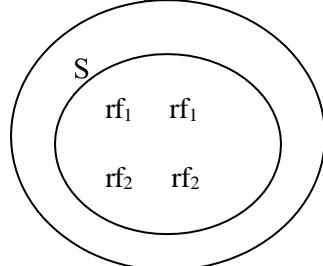
Male sterile

X

B line

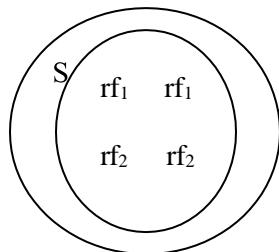


Male fertile



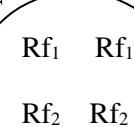
Male sterile A line

hybrid rice production

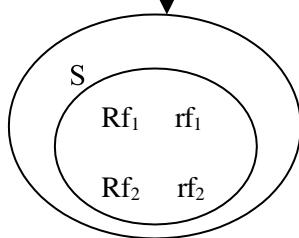


A line

X



R line



Fertile F₁ hybrid rice

International Rice Research Institute Philippines

- I R R
- NRRI – National Rice Research Institute Cuttack (orissa)
- DRR Directorate of Rice Research Hyderabad. (A.P)

Name of the released varieties for different breeding objectives

1.	High Yielding Varieties	Swarna, Vijetha, MTU1000 (cottondorasannalu) Jaya.
2.	Early maturity	Cottondorasannalu, Tellahamsa, Jagtial Sannalu, IR-64
3.	Resistant to lodging and shattering	MTU 1061 (Indra) MTU 1064 (Amara)
4.	Resistant to cold temperature	Tellahamsa, Erramallelu
5.	Resistant to salinity	Vikas, CSR-30 (Yamini), Swarnamukhi (NLR145 CSR 29) Swarna
6.	Resistant to diseases	Blast: NLR-145, Somasila Swathi, Shravani
7.	Resistant to pests	BPH: Vajram, Vijetha Deepti, Krishnaveni Gall midge : Kavya, Surekha Jagtial sannalu
8.	Aroma	Short slender: Chittimutyalu, Kala namak Long slender: Pusa Basmati1, Pusa 1121, Vasumati, Sumati
9.	Red rice	Heera
10.	Deep water	PLA 1100
11.	Dryland conditions	Rasi, MTU 9993 Erramallelu

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MAIZE (*Zea mays*) $2n = 20$

Corn is the queen of cereals and it is the important crop next to rice and wheat with regard to total area and production. It is studied to a much wider range of climatical conditions than rice and wheat, because of its greater adoptability.

Origin: Central America

Distribution: USA, China, Russia, Canada and many south Asian countries

Progenitors: *Zea tunicata*

Z. teosinte

It belongs to the tribe Maydeae of family gramineae.

Wild relative: Teosinte: There are three species of teosinte of which *Zea mexicana* is annual diploid ($2n = 20$) like maize.

Gamma grass another close relative belongs to genus *Tripsacum*

The genes *Zea* characterized by male terminal inflorescences with paired staminate spikelets and lateral female inflorescences with single or paired pistil late spike lets

Genus Zea contains four species

1. *Zea mays* ($2n = 2x = 20$) = Corn
2. *Zea mexicana* ($2n = 2x = 20$) = Annual teosinte
3. *Zea perennis* ($2n = 4x = 40$) = Perennial tetraploid teosinte
4. *Zea diploperennis* ($2n = 2x = 20$) Perennial diploid teosinte

B reeding objectives :

1. Yield :

Complex character controlled by polygenes. Attention is to be paid to have ideal plant type. Varietal hybridization as a maize breeding method did not gain popularity. The main reason for this is difficulty in getting superior segregants.

2. Breeding for pest and disease resistance :

Shoot fly, Stem borer, Heliothis are major pests. Mexican varieties are resistant. Downy mildews, leaf blight and helminthosporium are major diseases. Co1, CoH 2 are resistant. Taiwan lines are resistant to downy mildew.

3. Breeding for high protein :

Composed of two fractions. a) Protein in endosperm known as *Zein* which is nutritionally not balanced since it is lesser in lysine and tryptophan. 80% protein found in endosperm.

b) Protein in germ (embryo) 20% balanced one. By increasing the embryo size we can increase protein content.

4. Breeding for increased oil content.

12-15% in germ. By increasing the embryo size we can increase oil content.

5. Alternate sources of cytoplasm

CMS - T. susceptible to helminthosporium, C and S Resistant.

6. High yielding baby corn.

Zea mays. variety *sachharata* , Sweet corn. The green cobs can be eaten as salad. The cobs can be harvested 45 days after sowing. CoBc 1 is latest variety of baby corn.

B breeding methods:

1. Introduction :

Initially the varieties were all introduced one.

Sikkim primitive 1

Sikkim primitive 2.

Mexican line were first introduced during 16th century by Portuguese

2. Mass Selection : Prior to 1945 mass selection was the only method used for maize improvement.

KT 1 - U. P.

RAS 1 - Rajasthan.

By adopting mass selection technique it is possible to get yield increase by 19% per cycle.

3. Ear to Row Selection :

First proposed by **Hopkins** for improving oil and protein content of maize. This method involves selection of a number of phenotypically desirable ears out of a population grown in isolation. The selected cobs are harvested on single plant basis and keeping part of the seeds and remaining sown in rows. Based on the best performing rows during next season the reserve seeds are sown.

This method is suitable for characters having high heritability like oil content and protein content. But it was not helpful to get increased yield.

4. Modified Ear to Row method :

Proposed by **Lonquist**.

- I. Best ear heads from population selected (100 No.) and harvested on single plant basis.
And threshed individually.
- II. The single heads harvested are raised in progeny rows in more than one location representing different environment with local checks.
- III. In the main station the progeny rows are used as crossing block. Pollen from best plants are collected, mixed and used for crossing the rows.

Select best five plants from each rows and harvest them separately record the yield.
On the basis of performance of over all locations only top 20% progenies are selected.
These 20% will include the five plants selected.
- IV. The seeds from 5 plants selected are sown in progeny rows and cycle is repeated.

5. Hybridization and Selection

Not popular since isolation of superior recombinants was not made.

6. Heterosis breeding :

Instead of using CGMS lines, detasseling the female inbred line is followed in India.

Since use of CGMS line is costlier compared to detasseling it is not followed. Crossing the inbreds of indigenous x exotic origin resulted in release of best hybrids.

Indian x Indian - 24 to
43% yield increase. Indian
x U.S. dent – 58 % yield
increase

Indian dent x Caribbean Flint – 47 to 54 % yield increase

1. Single cross hybrid
2. Three way cross hybrids - Ganga -5, Trishulatha
3. Double cross hybrids - CoH 3
4. Double top cross hybrid - White kernel hybrids - Ganga safed 2, Histarch, Ganga 4.

7. Population Improvement:

Recurrent selection technique was initiated by Dhawan in 1963. The initial synthesis of composites were done from high yielding inter varietal crosses which exhibited minimum inbreeding depression.

Kisan, Jawahar, Vikram, Sona, Vijay, Amber.